PATENT SPECIFICATION

DRAWINGS ATTACHED

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Int. Cl.:—E 04 h 9/00

COMPLETE SPECIFICATION

Shelter for Protection from Explosion Shock Waves

I, SIDNEY MARSH CADWELL, a citizen of the United States of America, of 436, Washington Road, Grosse Pointe, Michigan, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION generally relates to a shelter structure for use against the dangers incident to war and, more specifically, relates to a protective structure which may be used to shield persons or equipment against the effects of the shock waves arising from atomic and other explosions.

With the advent of modern warfare and the use of atomic, chemical and biological weapons, it becomes necessary to protect our retaliatory personnel and equipment from the effects of these weapons. This protection is required if we are to be capable of delivering a retaliatory offensive in the event these weapons are used in committing a nation to war. While certain devices and structures are presently available for this use, they do not provide the degree of protection required as compared to the weight and expense involved. In certain cases, the prior structures and devices are too cumbersome to afford any degree of mobility to the user.

In providing protection of equipment against the blast effects of an atomic explosion a structure may be pressurized to a degree such that the shock wave force of the explosion is not transmitted through the structure and into the pressurized interior thereof. In protecting personnel, in addition to equipment, by placing a pressurized envelope between the blast and the personnel, the envelope having been pressurized to a pressure which is greater than the shock wave pressure, the shock wave will be reduced to near zero before entering the interior of the envelope. In a specific example, by using a fabric reinforced rubber envelope inflated to a pressure greater than the total shock wave pressure that is to be expected, the shock wave produced by the explosion will not be transmitted to the interior thereof, measuring equipment placed within the structure failing to register any appreciable indication of the presence of the shock wave. Thus, personnel and equipment placed within the envelope would be protected against explosion shock waves. In view of the sealed envelope and the thickness thereof, the personnel would also be protected from toxic or corrosive gases and bacteria.

More specifically and merely as an example, a missile of the type which is normally mounted in a vertical position and ready to fire, can be enclosed in a fabric reinforced rubber envelope which has been suitably sealed and supported in the upright position. The interior of the envelope is inflated to a pressure which is greater than the total shock wave pressure which could be anticipated from an atomic explosion at the assumed distance that the envelope is placed from the point of explosion. It has been found that the missile would be protected against the forces of the shock wave, the fire wave, wind and certain of the radiation effects of the blast which would be encountered at a missile site. In determining the pressure to which the interior of the envelope is to be inflated, it is necessary that a calculation be made as to the total blast pressure or total shock wave pressure which could be expected at that point.

These calculations can normally be made by estimating a probable ground zero area in the vicinity of the missile site; and, through the known relationship that the shock wave

[1

pressure decreases inversely as the cube of twice the distance from the explosion, the pressure at the missile site may be calculated. It is anticipated that the required inflation pressures will normally range from 5 to 1000 pounds per square inch, thus effectively protecting equipment and personnel that are reasonably near to an atomic explosion. It is to be understood that the pressure utilized must be such as can be confined within a flexible envelope.

According to the invention there is provided a shelter for protecting equipment and/or personnel against the effects of an explosive shock wave comprising a flexible envelope enclosing a cavity, said envelope being adapted to receive and enclose therein the equipment and/or personnel to be protected, the cavity being pressurized with gaseous fluid to a predetermined pressure which is greater than atmospheric pressure by at least 5 lbs per square inch whereby the equipment and/or personnel when disposed in the shelter is at least substantially surrounded by said pressurized fluid whereby protection will be given to equipment and/or personnel within the shelter against a shock wave having an overpressure when reaching the cavity of not more than said predetermined pressure.

A simple form of the device can be fabricated from a rubber exterior or outer covering with a single or plurality of layers or plys of weftless or woven fabric. The fabric may be constructed of any of the natural fibres, such as cotton, silk, wool, or any of the synthetic fibres such as nylon, rayon or polyethylene terephthalate. It is further contemplated that the plys could be constructed of such materials as steel or glass weftless or woven fabric. In cases where the pressure within the structure is extremely low, little or no reinforcement will be necessary and the structure may be wholly constructed of a thick wall of carbon black reinforced rubber or other material. It is contemplated that the thickness of the rubber in this latter case will be of the order of one-fourth to one inch in thickness, depending on the internal pressure of the envelope. If greater thicknesses are utilized, a certain amount of attenuation of the shock wave will be achieved within the wall itself.

While the flexible envelope will be described as being primarily composed of rubber and fabric, it is to be understood that any polymeric material that is solid and, importantly, is somewhat flexible at ordinary temperatures may be used. These materials include synthetic rubbers and plastics materials. Other considerations in the exterior covering are the ability to withstand heat and the radiation effects of the atomic blast along with the characteristic of being impervious to chemical and bacteriological materials which may be used. Similarly, the exterior covering may be chosen for its capability of inherently attenuating shock waves; and, in this regard, it is to be noted that rubber has an inherent characteristic of attenuation of shock waves, the attenuation being proportional to the thickness of the rubber employed.

When using the invention for the protection of personnel in addition to equipment, it is preferred that the structure be built up of a double wall configuration, the wall construction being of the type described above, with the portion between the two walls pressurized to a pressure which will be greater than that contemplated by the atomic blast at the site of the personnel. Through this double wall construction it is only necessary that the space between the two walls be pressurized and the interior of the structure may be maintained at atmospheric pressure. In this way, it is not necessary that the personnel contained in the shelter wear pressurized suits or other encumbering apparatus.

In this double wall construction, it is contemplated that the wall will preferably be compartmentized or constructed of a plurality of air pockets, with each compartment pressurized to the calculated pressure. Thus, the possibility that the pressurizing fluid would escape from the whole envelope if the envelope were punctured is precluded. If the fluid were lost from the whole envelope, the personnel contained therein would be vulnerable to subsequent blast and radiation effects.

It is contemplated that part or all of the surfaces of the reinforced rubber may be covered with plates of metal or other solid material or a portion of the surface structure may be metal with other portions of rubber construction. As an example, in the case of a submarine, it is contemplated that a double metal wall would be built up around the submarine with a pressurized double wall construction disposed between the two separated metal walls. The inner metal may be the outer hull of the submarine or vessel. Thus, the pressures which are impressed on the exterior of a submarine, due to the explosion of depth charges or the like, will be reflected to the point where the force will not be transmitted from the exterior metal wall to the interior metal wall.

In this way, the waterproof inner metal coverings of the submarine will not be penetrated or buckled due to the explosion, thus precluding the entry of water to the interior of the submarine. Similarly, certain portions, or all areas, of surface ships may be enclosed in a structure of the type described above; that is, the double wall construction, to protect personnel or equipment which may be contained therein. Thus, in the case of a landing ship, the personnel which are con-

tained within the interior of the landing ship may be protected from blasts by providing a protective covering of the type described above.

In choosing the fluid with which the structure is to be pressurized, it is contemplated that air or nitrogen are preferable gases to be used, but any permanent type of gas may be chosen. In choosing the gas for inflating the structure, due consideration must be had to the diffusibility, combustibility and explosibility of the gas. It is preferable to have a gas which is inert in its explosive or combustive character and diffuses only slowly, and it is further desired that the gas be electrically insulating.

The invention will be described, merely by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a representative illustration in cross section of a missile silo wherein the present invention is being utilized;

Figure 2 is a cross-sectional view taken along lines 2—2 of Figure 1, illustrating one preferred construction of the walls of the structure of Figures 1 and 2;

Figure 3 is a cross-sectional view of a shelter for personnel and equipment utilizing the present invention;

Figure 4 is an illustration in cross section of another embodiment of a structure for use in protecting personnel and equipment;

Figure 5 is a cross-sectional view of the door structure to be utilized in the shelter illustrated in Figure 4;

Figure 6 is a cross-sectional view of the door structure of Figure 5 illustrating the door in position on the shelter of Figure 4; and

Figure 7 is a cross-sectional view partially illustrating a construction embodying the invention for use in protecting submersible or surface vessels or land vehicles.

Referring now to Figure 1, there is illustrated a silo 10 containing a missile 12 therein of the type which is either adapted to be fired while still within the silo, or may be raised to a point above the level of the ground for firing. The silo 10 is constructed of a concrete casing 14 which surrounds the missile 12 and which has a pair of access tunnels 16 and 18 emanating therefrom. The lower portion of the silo 10 is provided with a pad assembly 20 which supports the missile 12 and may be used to raise the missile 12 above the ground into firing position. Interposed between the walls 14 of the silo 10 and the missile 12 is a pressurized envelope 22 utilizing the present invention.

In constructing the silo 10, a portion of the earth 24 is dug out and suitable forms are provided to fabricate the walls thereof. The upper portion of the silo 10 is provided with a door mechanism 26 having a pair of doors 28, 30 which may be opened just prior to the firing of the missile 12. The access tunnels 16 and 18 are integrally formed with the walls of the silo and provide easy access to the missile for testing and inspection purposes. The floor of the silo 10 is provided with the pad assembly 20 which includes a raising and lowering mechanism, partially illustrated as structural elements 32, 34 and 36, and a source of power (not shown) to provide power to the structural elements 32, 34 and 36, thereby raising the missile into the firing position. Intermediate the ends of the silo, a second floor 38 is provided for a purpose to be hereinafter explained.

The shelter assembly 22 generally comprises a reinforced rubber envelope 40, which is of a construction to be hereinafter explained, and a support pad 42 contained therein which is adapted resiliently to support the missile 12 within the envelope 40. The envelope 40 is constructed of a generally circular side wall section 43 and a bottom 44 integrally formed therewith. The top of the envelope 40 is provided with a pair of overlapping ends 46, 48 which are suitably sealed to each other as by a sealant 50. The method of sealing the upper portion of the envelope 40 is not critical to the invention, but it is contemplated that the upper surface of overlapping portion 46 may be suitably fastened against the cover portion 52 of the intermediate cover 38 with the upper surface of the other overlapping portion 48 bearing against the lower surface of the overlapping portion 46 with the sealant 50 maintaining the two portions 46, 48 in position.

The interior 54 of the envelope 40 is suitably pressurized with pressurizing means comprising fluid admitted through a pressure inlet valve 56 which may be of any known construction. Thus, as the interior 54 is pressurized to the desired predetermined pressure of at least 5 lbs per square inch, the overlapping portion 48 is forced outwardly into sealing engagement with overlapping portion 46. The sealant 50 may be of any compressible, tacky substance which will adhere to member 46 under pressure and may be released on a relief of the pressure in envelope 40.

The envelope 40 is suitably held in place by fastener brackets 60 which may be of any construction or of the configuration illustrated in Figure 1, and which are embedded into the side walls 14 of the silo 10. A suitable pressure gauge 62 is also provided which is adapted to read the interior pressure of the envelope 40 and the exterior pressure or atmospheric pressure in a normal situation, or shock wave pressure in a situation where an explosion has occurred. Thus, the operating personnel of the missile site may be provided with information as to the

differential pressure between the interior and exterior of the envelope 40.

In operation, and when it has been determined that an explosion has occurred, the operating personnel watch the indication of the pressure gauge 62 for an indication that the pressure in the area exterior to the envelope 40 has dropped to atmospheric pressure. This indicator preferably will be mounted at a remote position from the gauge 62. In this regard, it is to be noted that the initial shock wave pressure caused by the blast will be registered and a second shock wave pressure will be registered sometime later, the second pressure being caused by the rush of air and debris into the vacuum created by the explosion. It is not until after the second pressure indication that the missile will be readied for operation. When it is decided to fire the missile, the door 52 is operated along the doors 26 and 28, thus opening the way to the exterior of the silo 10. When door 52 is open, the upper overlapped portion 46 will be carried therewith, and any suitable mechanism will be provided to open or extend the lower overlapping portion 48. In this regard, suitable conventional interlocking mechanism between overlapping portions 46 and 48 may be provided. With the opening of the overlapping portions 46 and 48, the pressure within the envelope 40 will be reduced to atmospheric pressure and the missile will be ready for operation. If the missile is to be raised from the silo, sufficient power should be provided to shear the clamping members 60 from the wall 14 of the silo 10 in order to free the missile 12 and its envelope 40 from the silo. In the alternative, the pad 20 may be made smaller than the bottom 44 and the envelope 40 will be inverted as the missile 12 is raised.

Figure 2 representatively illustrates one preferred construction of the wall of the envelope 40. As is seen from Figure 2, the wall is constructed of an exterior layer 70 of rubber or other material, as described above, with a plurality of layers or plys of reinforcing fabric 72 provided on the interior thereof. The interior of the wall is provided with an inner sealing liner 74 which prevents any appreciable mount of the pressurized fluid from entering the plys 72 and separating them or separating the plys 72 from the exterior layer 70. The plys 72 are built up of a plurality of layers of fabric such as would be normally found in a tyre construction. As stated above, these plys may consist of weftless fabric or woven fabric formed of any natural or synthetic fibres as well as steel or glass. The plys are utilized primarily for structural rigidity and strength and are suitably chosen for these characteristics.

Referring now to Figure 3, there is illustrated an alternative embodiment of the present invention which may be primarily utilized for protecting equipment which is operated by personnel and the personnel which may be contained therein. The structure 78 is representatively illustrated as being constructed of an open ended barrel-shaped member 80 with an upper end member 82 and a lower end member 84 closing off the ends of the barrel member 80. The personnel and equipment are enclosed within the space provided between members 82 and 84. The interior of barrel member 80 is lined with a tubular steel liner 85 to support member 80 and a top disc 87 and bottom disc 89 are provided for additional strength. It is to be understood that member 80 may additionally include suitable structural truss members, not shown, for structural rigidity.

The walls of members 80, 82 and 84 are constructed of a double wall member 86 having an outer wall 88 and an inner wall 90 joined at either end by a layer of rubber 92, 94 to seal the ends thereof. As a certain amount of pressure may enter at the point where the top 82 is joined to barrel member 80 and the bottom 84 to member 80, a pair of generally circular pressurized fillets 91, 93 have been provided. It is to be noted that the interior of the fillets 91, 93 are hollow and pressurized as in the case of the members 80, 82 and 84 to reflect any shock wave encountered at the juncture of members 82, 80, and 80, 84. At least one and, in many cases, a plurality of intermediate rib members 96 are provided intermediate the ends of the wall members 86. Thus, the barrel-shaped wall member 86 is suitably compartmentized by the plurality of intermediate members 96, which provide air pockets 98 and 100 within the wall member 86. As described above, this compartmentizing provides additional safety for the interior of the barrel member 86 to provide against the contingency of foreign objects puncturing one of the compartments 98 or 100, and precluding the loss of the entire pressurized area between the outer wall 88 and inner wall 90. It is to be noted that the wall 86 is provided with additional members (not shown) which extend longitudinally of the barrel-shaped member 80, thereby compartmentalizing the structure in the transverse direction, The top and bottom members 82 and 84 are similarly formed, thus providing a cellular type structure for the whole construction.

The top and bottom members are suitably attached to the barrel member 80 by any method which will provide rigidity and strength to the structure. It is to be noted that access to the interior of the structure must be provided and this may be done through any suitable access opening (not shown) in the top 82 or in the barrel member 80. The wall construction 88 and 90 and the wall construction of the top and bottom

outer wall 82 and 84 are formed similar to that shown in Figure 2, and the outer wall 88 is turned back to back with the inner wall 90 and the upper and bottom members are similarly constructed. The interior of the member 80 is provided with the equipment to be protected along with an air-conditioning and oxygen unit 102 to provide oxygen and comfort to the personnel and additionally to lower the temperature in the structure due to the heat dissipated by the equipment contained therein. It is contemplated that the site at which the structure of Figure 3 is used may be sufficiently spaced from the anticipated point of explosion of the atomic weapon such that the top 82 may be omitted, thereby still providing protection against blast effects for the equipment and personnel contained within the structure 78.

As an alternative use of the construction illustrated in Figure 3, it is further contemplated that the member 80 may be used or a pair of rectangular members of the construction illustrated in Figure 3 be placed at a point spaced from the point of explosion and personnel could position themselves between the two rectangular members. In this use, the rectangular members will be positioned with the flat side thereof facing the point of explosion thereby protecting the personnel from the direct blast. The back portion or other wall will be placed behind the personnel further spaced from the point of explosion to protect the personnel from the counterblast which will be produced by air and debris rushing into the vacuum created by the initial blast. In this way, an extremely simplified and easily transportable structure is provided for the protection of personnel and equipment. It is anticipated that this structure will be utilized in an area where the pressure would not be too great as to endanger the personnel.

Referring now to Figures 4, 5 and 6, there is illustrated another modification of the structure of Figure 3, adapted to be utilized in protecting personnel and equipment. In Figure 4 there is shown a hemispherical dome-type shelter 110 which is generally constructed of an inner steel or similar metal shell 112 and an outer shell 114, spaced therefrom and constructed or rubber or other suitable material. It is to be noted that the outer shell 114 may be formed solely of a rubber layer or may be formed of a construction similar to that illustrated in Figure 2. The two shells, 112 and 114, are suitably anchored at the lower edges thereof by embedding the edges in concrete or attaching them to a series of concrete posts 116 by means of a plurality of fasteners 118. The space between the inner shell and outer shell 114 is pressurized to a pressure which sufficient to reflect the explosive shock wave which may be anticipated, as described above. The floor of the shelter is protected from any bomb tremors or other shock waves received generally upwardly from the ground by means of a pressurized floor assembly 120 which may be compartmentalized, as described in conjunction with Figure 3, and is pressurized to a pressure which is of the same order of magnitude as the pressure between shells 112 and 114.

The floor assembly 120 may be formed of a plurality of generally concentric circular compartments having a plurality of cavities 122 formed therein which are suitably attached to each other in any well known manner, as for example by attaching in a moulding process. Also, the floor may be formed of a plurality of small, closely spaced cells, as would be the case in the cellular structure of greatly magnified foam or other closed cell material. However, to facilitate the pressurizing of the floor assembly, it is contemplated that the concentric circular structure would be preferable. The interior of the structure may be provided with visual access to the exterior of the dome 110 by means of a periscope 124 and suitable air conditioning equipment 126 or other convenient facilities, such as a lavatory and washing facilities.

Entrance to the dome structure of Figure 4 may be provided with a door assembly 129, the details of which are illustrated in Figure 5 and 6. A door 128 is provided in the dome structure and is of a similar steel construction as the liner 112 to provide the same structural rigidity as the dome structure. The exterior of the door 128 is covered with a pressurized cover assembly similar to that illustrated in Figure 3, that is, the covering assembly comprises an outer wall 130 and an inner wall 132 joined by a plurality of webs 134. Similarly, a plurality of longitudinally extending webs (not shown) may be provided further to compartmentalize the interior structure between the walls 130 and 132. As in the previous cases, the cavities of the shells provided by walls 130, 132 and 134 would be pressurized by pressure which was of the same magnitude as the pressure between shells 112 and 114.

Figure 6 illustrates the door structure 129 in the closed position and it is to be noted that the upper portion of the door overlaps the lower portion of the outer shell 114 which converges with shell 112 to provide a sharp angle between the inner shell 112 and outer shell 114. While the pressure between shell 112 and 114 would be the same at this area as in other areas of the dome structure, the portion of the dome structure where the two shells 112, 114 meet, would have to be protected by a pressurized area; thus an overlapping is provided. Similarly, at the bottom, a close fit between the ground and the door 129 is provided to preclude shock wave

pressure from entering the interior of the dome at a point adjacent the ground level.

Figure 7 illustrates a further embodiment of the present invention which is particularly adapted to be utilized on submerged vehicles such as submarines, diving bells, submerged equipment and other like objects. Also the construction illustrating Figure 7 may be utilized on the hull of a surface ship or other vehicles to provide protection from torpedo or bomb explosions which may occur adjacent a ship.

The modification is only partly shown, and it is to be understood that the structure illustrated would be provided around the complete exterior of the ship or vessel of the type described. The structure is applied to an outer hull 140 of the ship and a second blister wall 142 has been applied thereto spaced from the hull 140. The space between the two metal walls 140, 142 is filled with a cellular structure 144 fabricated of a generally flexible material. The cellular structure 144 may be composed solely of a layer of rubber or may be formed of the wall construction illustrated in Figure 2. The structure 144 generally comprises a pair of walls 146, 148 which are joined at their ends by webs 150 suitably to seal the sides of the cell. The interior of the cell is pressurized to a pressure which is greater than the expectant shock wave pressure reaching the interior of the cell from an explosion which may occur nearby. Thus, the force of the explosion hitting the blister wall 142 will be transmitted through to the wall 148 and thence reflected back through the wall 142. With this type of construction applied to the exterior or surface of a ship, torpedo or bomb explosions which may occur in the vicinity of a surface vehicle or depth charge explosions in the case of a submarine, will be reflected and the hull 140 will remain intact, thereby precluding the flooding of the interior of the vessel. It is to be understood that this construction may also be used on land vehicles, such as personnel carriers, trucks or the like, to provide protection for the personnel or cargo contained therein from shock curves in the surrounding air.

WHAT I CLAIM IS:—

1. A shelter for protecting equipment and/or personnel against the effects of an explosive shock wave comprising a flexible envelope enclosing a cavity, said envelope being adapted to receive and enclose therein the equipment and/or personnel to be protected, the cavity being pressurized with gaseous fluid to a predetermined pressure which is greater than atmospheric pressure by at least 5 lbs per square inch whereby the equipment and/or personnel when disposed in the shelter is at least substantially surrounded by said pressurized fluid whereby protection will be given to equipment and/or personnel within the shelter against a shock wave having an overpressure when reaching the cavity of not more than said predetermined pressure.

2. A shelter according to claim 1, wherein the flexible envelope has a core formed of a fabric ply and an exterior covering of a flexible material.

3. A shelter according to claim 2, wherein the flexible envelope has a plurality of overlying fabric plies and an exterior covering of rubber like material.

4. A shelter according to claim 2 or 3, wherein the interior of the envelope is formed with a sealing liner for preventing escape of the fluid.

5. A shelter according to any preceding claim, wherein the envelope has an interior wall and an exterior wall separated therefrom, the pressurized cavity comprising the space between the interior and exterior walls.

6. A shelter according to claim 5, wherein the interior and exterior walls are formed of a core of layers of cotton, silk, wool, nylon, rayon and/or polyethylene terephthalate material and a covering of flexible material covering the exterior of the core.

7. A shelter according to claim 5 or 6, wherein the envelope is formed of a barrel-shaped side member and a disc-shaped top member.

8. A shelter according to any preceding claim, wherein the interior of the envelope is hermetically sealed for protecting the equipment and/or personnel from the effects of atomic explosion and/or chemical and biological agents.

9. A shelter according to claim 1, wherein the envelope is generally cylindrically shaped for enclosing equipment to be protected, and is formed of a core of a plurality of layers of at least one of woven or weftless fabric and a layer of a flexible material covering the exterior of said core, means being provided to support the envelope in a generally vertical position.

10. A shelter according to claim 1, wherein there is provided a metal dome-like inner liner formed generally hemispherical in shape and having its edges sealed to a surface, the flexible envelope comprising a flexible dome-like outer liner formed generally hemispherical in shape having at least a portion thereof disposed spaced from the metal inner liner and having its edges sealed to the surface, and the space between the inner and outer liners comprising the pressurized cavity.

11. A shelter according to claim 10, which includes a door for gaining access to the interior of the shelter and comprising an interior metal liner and an outer structure formed of an outer flexible wall, an inner flexible wall spaced from the outer wall and

disposed adjacent the interior metal liner, flexible web means interconnecting the inner and outer flexible walls forming cavities for compartmentalizing the space, and compressible fluid pressurizing the cavities to the pressure at least as great as the overpressure of the shock wave reflected to the interior pressurized portion.

12. A shelter according to claim 10 or 11, wherein a pressurized floor assembly is provided within the inner liner and comprises a plurality of cavities pressurized with compressible fluid to a pressure of the same order of magnitude as said predetermined pressure.

13. A protective device for reflecting an explosive shock wave from the hull of a vessel or from a vehicle body comprising a rigid metal blister wall supported spaced from the hull of the vessel or the vehicle body, and a flexible envelope disposed in the space between the hull or body and said blister wall and including a first flexible wall disposed adjacent the hull or body, a second flexible wall disposed adjacent the blister wall forming with the first wall a closed cavity and a compressible fluid filling the cavity at a predetermined pressure at least 5 lbs per square inch greater than normal environmental pressure to give protection against a shock wave having an overpressure when reaching the cavity of not more than said predetermined pressure.

14. A protective device according to claim 13, wherein the first and second walls are formed of a layered core of overlying fabric plies and an exterior covering of rubber-like material, rubber-like web means interconnecting the first and second walls for compartmentalizing the space between the walls.

15. A protected weapon arrangement comprising a missile silo including a substantially cylindrical casing and a launch pad within the casing, a missile positioned on the launch pad, a generally cylindrically shaped flexible envelope surrounding the missile and spaced therefrom, said envelope being formed of a core of a plurality of layers of at least one of woven and weftless fabric and a layer of flexible material covering the exterior of the core, gas pressurizing the interior of the envelope to a predetermined pressure of at least 5 lbs per square inch greater than atmospheric pressure to give protection against a shock wave having an overpressure when reaching the interior of the envelope of not more than said predetermined pressure, and means supporting the envelope in a generally vertical position.

16. An arrangement according to claim 15, wherein the casing includes door means intermediate the ends thereof for opening the end of the flexible envlope and releasing the pressur therein.

17. Shelters for protecting equipment and/or personnel from explosions having shock waves substantially as herein described with reference to and as illustrated in the accompanying drawings.

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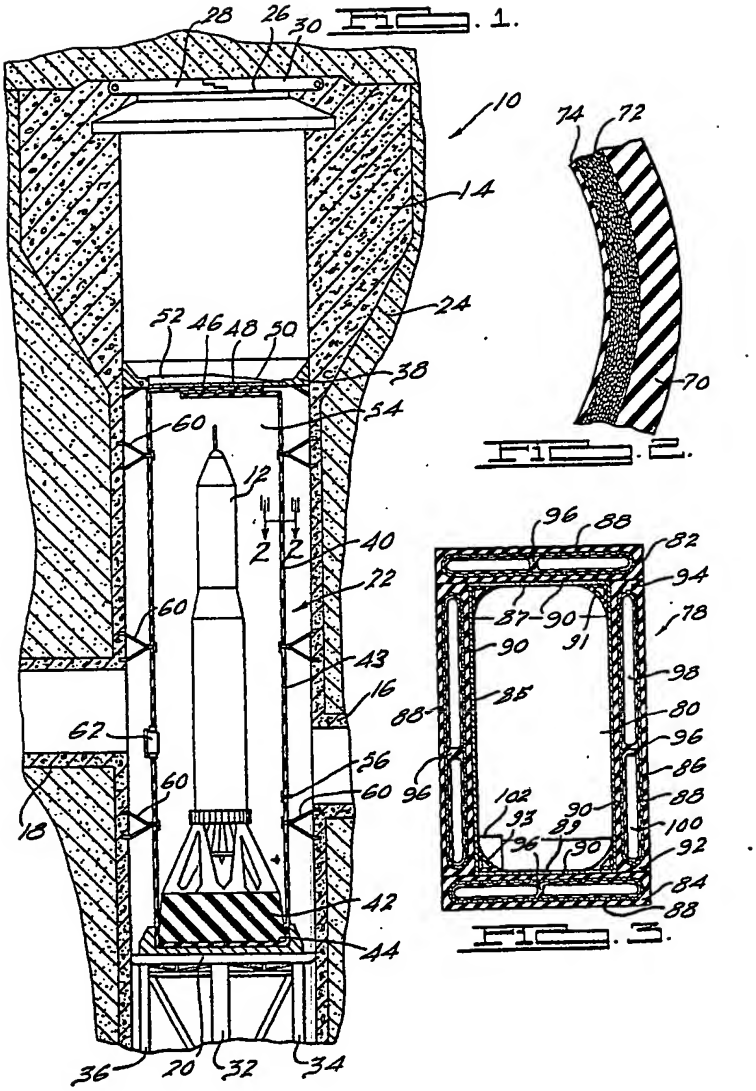

FIG. 1.

FIG. 2.

FIG. 3.

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FIG. 2.

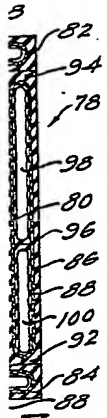

FIG. 3.

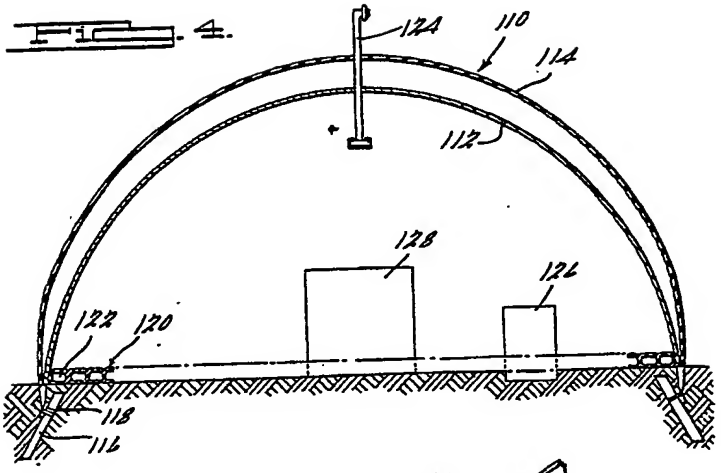

FIG. 4.

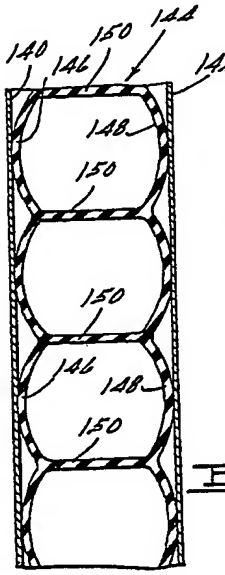

FIG. 7.

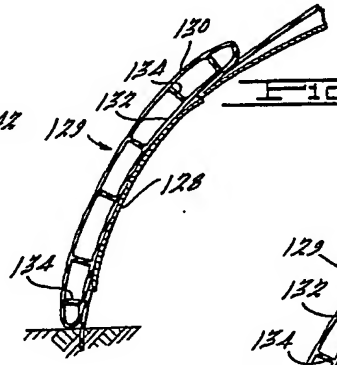

FIG. 6.

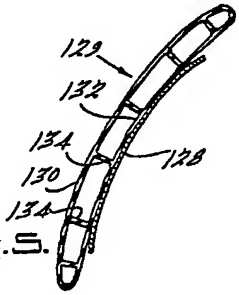

FIG. 5.

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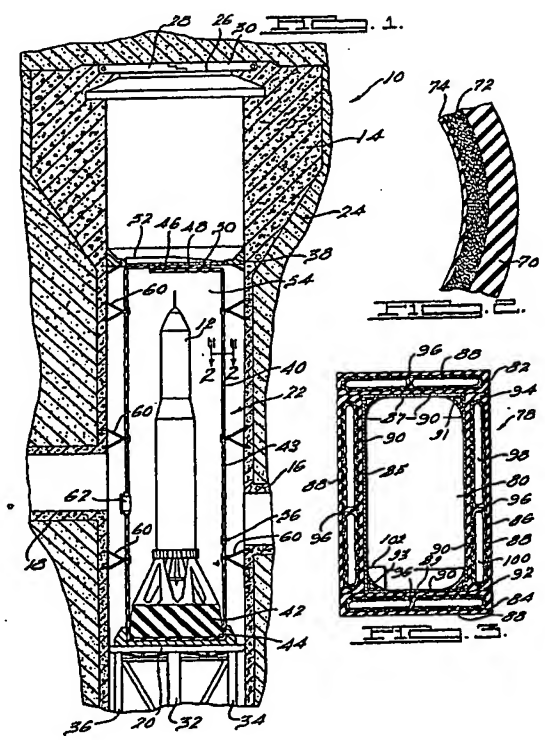

FIG. 1.

FIG. 2.

FIG. 3.

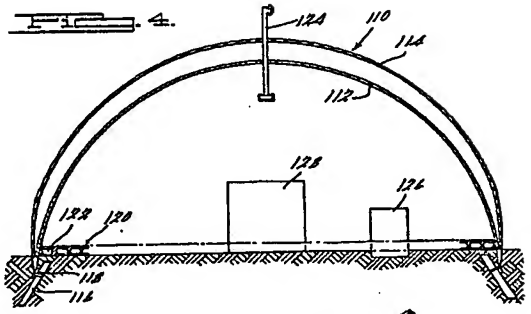

FIG. 4.

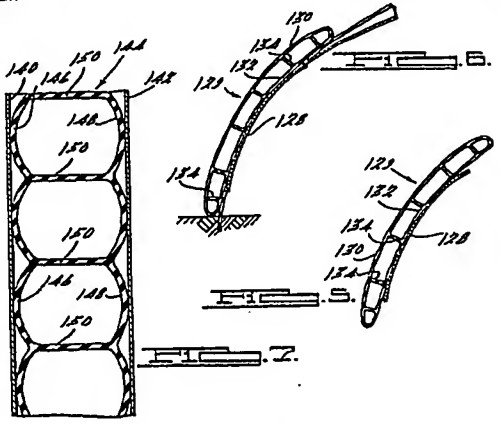

FIG. 7.

FIG. 6.

FIG. 5.